Application of a Detailed Thorax Model to Investigate Behind Armour Blunt Trauma

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I. INTRODUCTION

Behind Armor Blunt Trauma (BABT) may occur when personal protective armor is impacted and deforms dynamically to stop a projectile [1]. This dynamic deformation can lead to localized high-rate loading of the thorax and subsequent trauma to the thoracic cage and internal organs. BABT has been investigated using animal models [2] and post-mortem human subjects (PMHS) [3]; however, identifying the injury mechanisms for the purpose of improving protection design is challenging since BABT rates of impact fall in the transition from moderate rate automotive impacts (deformation and velocity effects) to high rate blast injuries (wave dominated effects). The goal of this study was to investigate thoracic cage injury for varying BABT impact severities using a detailed Three-Dimensional Torso Model (3DTM) (Fig. 1) [4] and simulated BABT loading.

II. METHODS

A mesh refinement study was undertaken on the thorax model and the model was impacted using BABT loading conditions (Fig. 2) (spherical impactor, 40 mm maximum deformation, 1.4 ms duration) determined from experimental studies. The impact force was compared to PMHS data, and the ribs and sternum were investigated for predicted fractures. Fracture was predicted locally within the hard tissues based on a small amount of effective plastic strain.

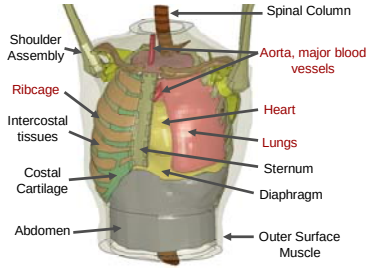

Fig. 1: 3DTM (oblique view)

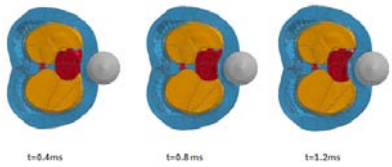

Fig. 2: Simulated BABT impact (transverse view)

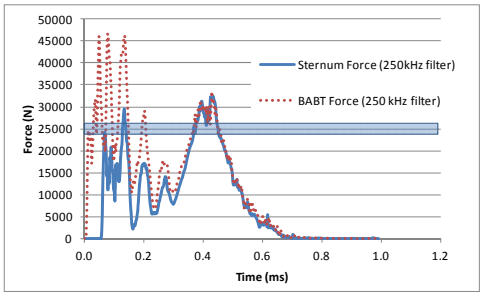

Fig. 3: Impact force

III. RESULTS

The model predicted increasing impact force for increasing impact severity, with significant deformation to the lungs and heart during the impact (Fig. 2). In general, the predicted BABT force on the thorax was higher than measured experimentally. However, when the force on the sternum, corresponding to the experimental measurements, was considered the peak force was reduced and delayed in time (Fig. 3). Transverse fracture of the sternum was predicted at a force of 28.7 kN, in agreement with the experimental data (24.9 ± 1.4 kN).

IV. Discussion and Conclusions

The detailed thorax model predicted transient response and thoracic cage injury for BABT impact conditions, including the type of fracture and contact force. Significant loading and deformation of the heart and lungs was identified and is the focus of future studies. The author gratefully acknowledges support from the US Army Research, Development and Engineering Command (W91CRB-11-D-0013) and Applied Research Associates.

V. References

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